7th World Rabbit Congress, Valencia Spain, 2000
Volume A, 573-578

EFFECT OF COOKING TEMPERATURE ON WARNER – BRATZLER TENDERNESS MEASUREMENT IN RABBIT MEAT

S. COMBES[1], A. AUVERGNE[2], F. LEBAS[1]

[1]INRA, Station de Recherches Cunicoles, BP 27, 31326 Castanet-Tolosan Cedex, France
[2]ENSAT, Laboratoire de Zootechnie, BP 107, 31326 Castanet-Tolosan Cedex, France

ABSTRACT

The effects of final internal cooking temperature (50, 60, 65, 70, 80 and 90 °C) on Warner-Bratzler (WB) tenderness measurement of *longissimus dorsi* (LD) in 45 and 70-day-old rabbits were investigated. Increasing cooking temperature revealed a three-phase effect on WB measurement. At 50 °C, peak shear force, and total energy were high (60 ± 8 N and 971 ± 194 mJ). Afterwards, they dramatically decreased to a minimum observed at 65°C (9 ± 2 and 128 ± 29 mJ). After 80°C, peak shear force and total energy values were as high as at 50°C (55 ± 7 N and 682 ± 111 mJ). Cooking loss exhibited a 30 % increase between 60 and 80 °C in both groups of age. Peak shear force and total energy values were lower (40 % and 60 % respectively $p<0.05$) in 45 than in 70-day-old LD samples. WB tenderness measurement differences between age groups were related to the differences in weight of the samples. This study indicates that increasing cooking temperature in the range 50 to 90°C, leads to a three-phase effect on rabbit meat texture which can be observed either in 45 or in 70-day old rabbits.

INTRODUCTION

The appreciation of meat texture can be made using a trained taste panel or by physical methods. Assessing tenderness using a taste panel is a relatively slow and time-consuming process. A large number of devices have been developed to evaluate mechanical tenderness. The most widely used to measure the toughness of meat is Warner Bratzler (WB) shear device (Harris and Shorthose, 1988). As the meat is usually cooked before eaten, it is important to understand the physical change of meat texture during heating.

Davey and Gilbert (1974) defined cooking as the heating of meat to a sufficiently high temperature to denature proteins. Temperature and duration of cooking have a large effect on physical properties of meat and eating quality. To date, different experimental techniques were used to cook rabbit meat : 80 °C for 2 hours (Xiccato *et al.*, 1994), 15 to 30 min in an electric oven pre-heated to 100 °C (Delmas and Lebas, 1998; Juin *et al.*, 1998) or 200 °C (Bernardini Battaglini *et al.*, 1994; Castellini *et al.*, 1998; 1999), or microwave cooked (Holmes, 1984). This different experimental technique of cooking made difficult the comparison of all the later studies because in most of them the final internal temperature cannot be clearly defined.

The present experiment was carried out to determine the influence of endpoint temperature cooking on rabbit meat WB tenderness measurement. Peak shear force value, total energy, displacement to the peak shear force and cooking loss were determined at 50, 60, 65, 70, 80 and 90 °C in 45 and 70 day-old rabbits.

MATERIAL AND METHODS

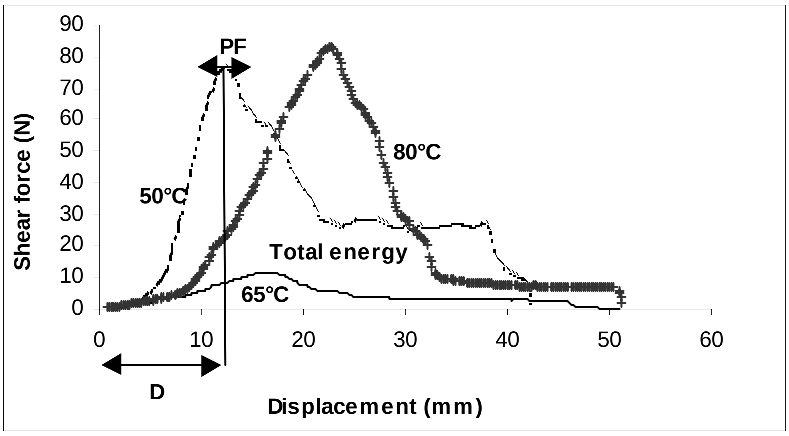
Animals :
Six 45 and six 70-day-old Hyplus x INRA 1067 rabbits were used in this experiment. After 24 hours aging both *longissimus dorsi* (LD) were removed and cut on in two equal parts (i.e. 4 LD samples per rabbit). In this experiment we chose not to standardise in core the samples

between age groups in order to shear the half of an intact LD muscle including the upper epimysial tissue. The obtained samples were weighed (5.9 ± 0.5 g and 20.3 ± 0.9 g for 45 and 70-day-old samples), and stored at –20 °C in vacuum-packed plastic bags.

Cooking :
Cooking was adapted from the procedure described by Honikel (1998). Briefly, the frozen LD samples were kept in their vacuum-packed plastic bag and thawed at 4 °C for 16 h. Plastic bags were totally immersed in a constant temperature water-bath at 50, 60, 65, 70, 80 or 90 °C. Penetration thermistor probes (HI 762 PW, Hanna Instruments) were used for temperature control inside a control sample for each water-bath. Internal sample temperature changes were monitored each minute. Endpoint temperature was reached in 10 and 15 minutes in 45 and 70 day-old samples respectively. After 1 hour heating, samples were removed from the water-bath, cooled under tap water for 20 minutes and remained at room temperature for 2 hours. Sample were weighed and cooking losses that included thawing losses were determinated.

Warner Bratzler shear test :
A single column ballscrew-driven (Mecmesin, model Versatest) complemented with a force gauge (Mecmesin, model PFI) was used. The Warner-Bratzler blade had 2 mm thick with a triangular hole in the middle. The blade travelled at 100 mm /min to the sample that was positioned so that the superficial epimysial side was the last sheared. The parameters measured from the force deformation curve (fig. 1) were the maximum shear force (N), displacement to the maximum shear force (mm) and total energy defined as the area under the force deformation curve (mJ).

Figure 1 : Typical WB shear force deformation curve for 70 day-old samples cooked for 1 hour either at 50 °C, 65°C or 80 °C. PF : peak shear force, D : displacement at the peak shear force, Total energy : area under the shear force deformation curve.



Statistical Analysis:
Experiment was conducted following an incomplete block design. Mean and standard deviations of the mean were calculated from the individual values using the software SAS, (1987). Firstly, analysis of variance was performed with age, temperature, weight of cooked samples and the interaction between age and temperature as the main effect. Because the interaction between age and temperature was significant for each parameter with exception of cooking loss, data were subsequently analysed separately for each temperature and each age.

Comparisons of the means between temperature were tested using the Student-Newman-Keuls procedure.

RESULTS AND DISCUSSION

Typical force deformation curves obtained in one animal at 50, 65 or 80°C are presented fig 1. Peak shear force values obtained were similar to those previously obtained in rabbit (Holmes, 1984; Bernardini Battaglini *et al.*, 1994; Castellini *et al.*, 1998; 1999).

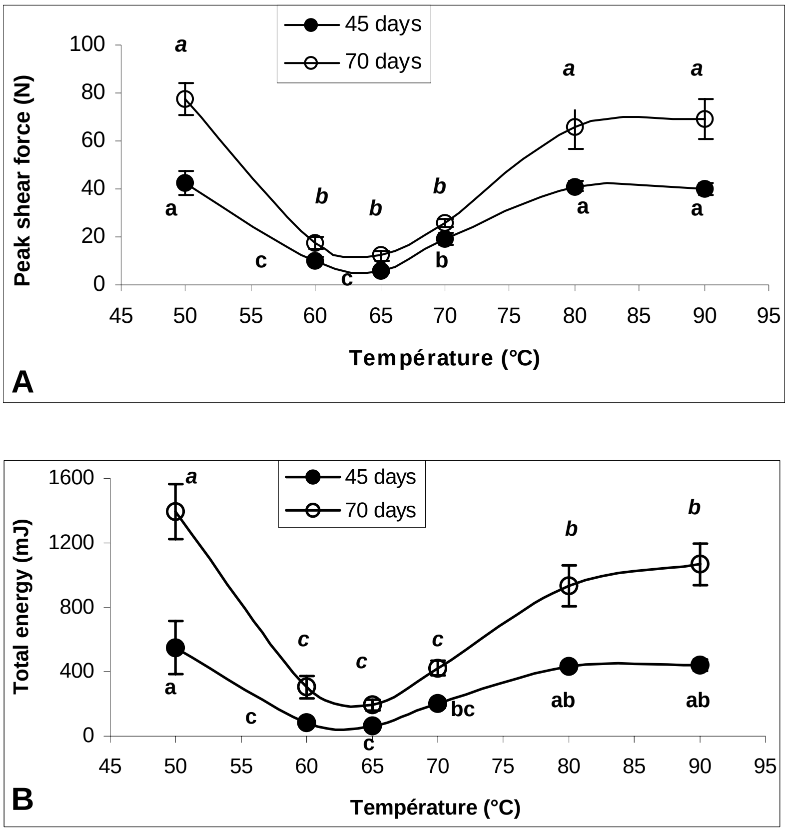
a. Effect of the cooking temperature :
Our results showed that WB peak shear force and energy values were high in LD cooked at 50 °C, reached a minimum value in those cooked at 60 – 70 °C and increase again after 70 °C (fig 2). Our data are in accordance with the study of Machlik and Draudt, (1963 cited by Harris and Shorthose, 1988) in beef, who observed that WB peak force values varied little in samples cooked up to 50 °C but decreased and reaching a minimum in those cooked at 60 – 64 °C. (Bouton *et al.*, 1981) reported the same effect of increasing cooking temperature on shear force value and demonstrated a slight increase in shear force value in sample cooked at 65- 80°C and a decrease thereafter.

The structure of meat can be regarded as a 2 components system made of myofibres and connective tissue. Hypotheses have been made to explain meat toughness by the relative contribution of myofibrillar and connective tissue structures. WB shear force would also result from the addition of the myofibrillar resistance and the connective resistance.

In the range 40 – 50°C, myofibrillar proteins undergo a thermal denaturation and form a gel more rigid than raw meat (Bailey and Light, 1989). In a preliminary experiment realised in our laboratory with the same technical conditions, peak shear force values of raw meat were around 40 ± 3 N in 70 day-old rabbits (n = 23 animals) (Lebas, unpublished data). The later observation associated with the high WB peak shear force value (77 ± 7 N in 70 day-old rabbits) seen in our report in samples cooked at 50°C is in agreement with the hypothesis of a myofibrillar denaturation phase related toughness.

The denaturation of collagen fibres occurs around 58 - 65 °C. The 80 % decrease in peak shear force values between samples cooked at 50 °C and those cooked at 65 °C could be related to the onset of collagen denaturation. In a first step, collagen fibres shrinkage induces a loss of resistance (Snowden *et al.*, 1978; Lepetit *et al.*, 2000). In a second step, with increasing cooking temperature, The further thermal contraction of peri- and endomysial collagen induces a compression of the myofibrillar structures and loss of water from the denatured actomyosin fibres which increase myofibre resistance (Bailey and Light, 1989). This second phase could correspond in our study to the increase in WB peak shear force value seen in samples cooked at 65 to 80°C which is concomitant with an elevation in cooking loss in both groups of age (fig 3).
Surprisingly, in our study, peak shear force and total energy values were as high in samples cooked at 50°C than those cooked at 80 °C in both groups of age. Bailey and Light (1989) explained this phenomenon by the probable partial reversion of the denatured collagen to a native collagen structure on cooling.

Figure 2 : Effect of cooking temperature on (A) peak shear force values (N) and (B) total energy values (mJ) of LD muscles from 45 and 70-day-old rabbits. Values are means ± standard deviations of the mean; n=4 ; a, b and c : Means within a group of age with different superscripts are significantly different. For each temperature, each group of age (45 vs 70 days) differed significantly ($p<0.05$)

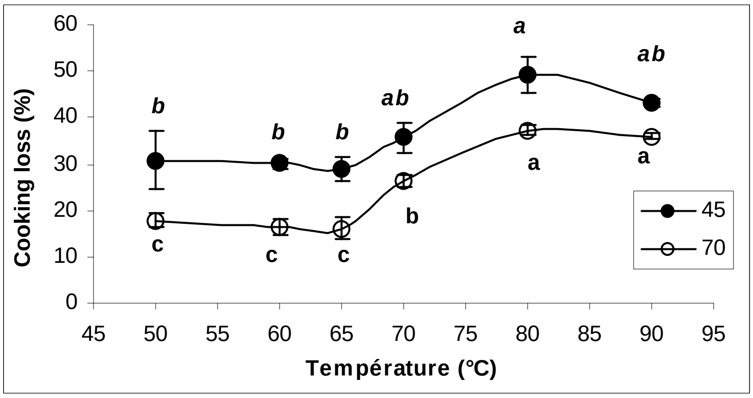


Over 65 °C, displacement at the peak force increased with increasing cooking temperature ($p<0.01$) (fig 4). Peak shear force occurs around 11.5 ± 1.7 mm at 65 °C and around 22.0 ± 1.2 mm in 70-day-old samples cooked at 90°C. This phenomenon corresponds to an increase in meat elasticity. It has been shown (Snowden *et al.*, 1978) that the more the collagen fibres contract the more their elasticity (deformation before yielding) increases.

b. Effect of age

Peak shear force and total energy values were lower ($p<0.05$) in 45 than in 70-day-old rabbits (fig 2) while cooking loss were higher in 45 than in 70-day-old rabbit. Bernardini Battagliani et al. (1994) found no difference in shear force value in cooked LD from rabbit at 75 and 90 days of age. In studies using training taste panel, loin muscle of 11-week-old rabbit was tougher than 18-week-old one (Juin *et al.*, 1998) while no differences in tenderness sensory was seen between rabbit loin at 10 and 12 weeks of age (Jehl and Juin, 1999). The discrepancy between our data and the later studies could be related to the differences in experimental conditions : mainly sampling method, cooking conditions and age of the animals. Indeed, in our study we chose to cook and shear the half of one intact LD. This means that the main age differences are widely related to the weight and geometrical differences of the samples. Our data are however in agreement with previous studies conducted in beef, where muscle exhibited a decrease in sensory as well as in WB tenderness measurement with increasing age (Bouton *et al.*, 1978; Bouton *et al.*, 1981). This age related change in meat tenderness notably after 65°C, may be explained by the elevation of the extent of collagen shrinkage with age due to an increase of the proportion of heat-stable cross-links between collagen fibre (Bailey and Light, 1989). Further studies are needed to ensure these hypotheses in rabbit.

Figure 3 : Effect of cooking temperature on cooking loss of LD muscles from 45 and 70-day-old rabbit. Values are means ± standard deviations of the mean; n=4 ; a, b and c : Means within a group of age with different superscripts are significantly different. For each temperature with the exception of 50°C, each group of age (45 vs 70 days) differed significantly ($p<0.05$)



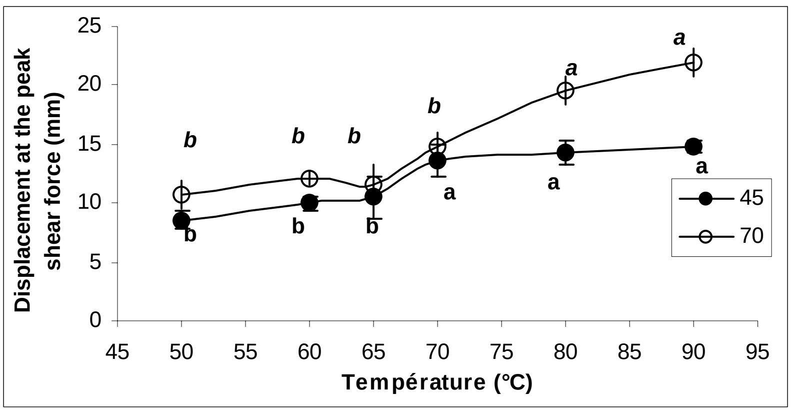
c. Which cooking temperature should be chosen to perform WB shear force measurement in rabbit meat?

Although the experiment should be completed and confirmed, from the present results one can recommend at least 80°C cooking temperature to performed WB shear force measurement. On a experimental point of view, at 80 °C, WB shear parameters become relatively constant. Moreover, it as been demonstrated (Juin *et al.*, 1998) that under 80 °C a taste panel has judged the meat not enough cooked.

CONCLUSION

In conclusion, the present study demonstrate for the first time in rabbit the effect of cooking temperature in the range 50 to 90 °C on meat WB tenderness measurement. The results show a three distinct phases effect of cooking temperature on meat tenderness which can be observed either in 45 or in 70-day old rabbits.. The second phase of toughness increase, observed between 65 and 80 °C, is associated in both groups with an elevation in cooking loss.

Figure 4 : Effect of cooking temperature on displacement at the peak shear force of LD muscles from 45 and 70-day-old rabbits. Values are means ± standard deviations of the mean; n=4 ; a, b and c : Means within a group of age with different superscripts are significantly different.



7th World Rabbit Congress, Valencia Spain, 2000
Volume A, 573-578

REFERENCES

BAILEY A.J., LIGHT N.D., 1989. Chap 8 - The role of connective tissue in determining the textural quality of meat. in: *Connective tissue in meat and meat products.* Eds. Elsevier Applied Science, London, UK., pp**:** 170-194.

BERNARDINI BATTAGLINI M., CASTELLINI C., LATTAIOLO P., 1994. Rabbit carcass and meat quality : effect of strain, rabbitry and age. *Italian Journal of food Science,* **2**, 157-166.

BOUTON P.E., FORD A.L., HARRIS P.V., SHORTHOSE W.R., RATCLIFF D., MORGAN J.H.L., 1978. Influence of animal age on the tenderness of beef : muscle differences. *Meat Science,* **2**, 301-311.

BOUTON P.E., HARRIS P.V., RATCLIFF D., 1981. Effect of cooking temperature and time on the shear properties of meat. *Journal of Food Science,* **46**, 1082-1087.

CASTELLINI C., DAL BOSCO A., BERNARDINI M., 1999. Effect of dietary vitamin E supplementation on the characteristics of refrigerated and frozen rabbit meat. *Italian Journal of Food Science,* **11**, 151-160.

CASTELLINI C., DAL BOSCO A., BERNARDINI M., CYRIL H.W., 1998. Effect of dietary vitamin E on the oxidative stability of raw and cooked meat. *Meat Science,* **50**, 153-161.

DAVEY C.L., GILBERT K.V., 1974. Temperature dependent cooking toughness in beef. *Journal of the Science of Food and Agriculture,* **25**, 931-938.

DELMAS D., LEBAS F., 1998. Exsudation en cours de conservation et pertes de jus à la cuisson de morceaux de râble de lapin : effet de l'âge. *7èmes Journées de la Recherche Cunicole en France* , 115-118.

HARRIS P.V., SHORTHOSE W.R., 1988. Meat Texture. in: *Developments in meat science.* R. Lawrie Eds. Elsevier Applied Science, , 4pp**:** 245-296.

HOLMES Z.A., 1984. Proximate composition and sensory characteristics of meat from rabbits fed three levels of alfalfa meal. *Journal of Animal Science,* **58**, 62-66.

HONIKEL K.O., 1998. Reference methods for the assessment of physical characteristics of meat. *Meat Science,* **49**, 447-457.

JEHL N., JUIN H., 1999. Effet de l'âge d'abattage sur les qualités sensorielles de la viande de lapin. *8èmes Journées de la Recherche Cunicole en France*, 85-88.

JUIN H., LEBAS F., MALINEAU G., GONDRET F., 1998. Aptitude d'un jury de dégustation à classer différents types de viande de lapin selon des critères sensoriels : aspects méthodologiques et application à l'étude des effets de l'âge et du type génétique. *7èmes Journées de la Recherche Cunicole en France*, 123-126.

LEPETIT J., GRAJALES A., FAVIER R., 2000. Modelling the effect of sarcomere length on collagen thermal shortening in cooked meat : consequence on meat toughness. *Meat Science,* **54**, 239-250.

SAS 1987. Statistical Analysis System/STAT guide for personal computers. Cary, NC, SAS Institut Inc.

SNOWDEN J.M., BOUTON P.E., HARRIS P.V., 1978. Influence of animal age on the mechanical properties of restrained, heat-treated collagenous tissue. *Journal of Food Science,* **43**, 178-201.

XICCATO G., PARIGI-BINI R., DALLE-ZOTTE A., CARAZZOLO A., 1994. Effect of age, sex and transportation on the composition and sensory properties of rabbit meat. *40th International Congress of Meat Science and Technology*, 52.